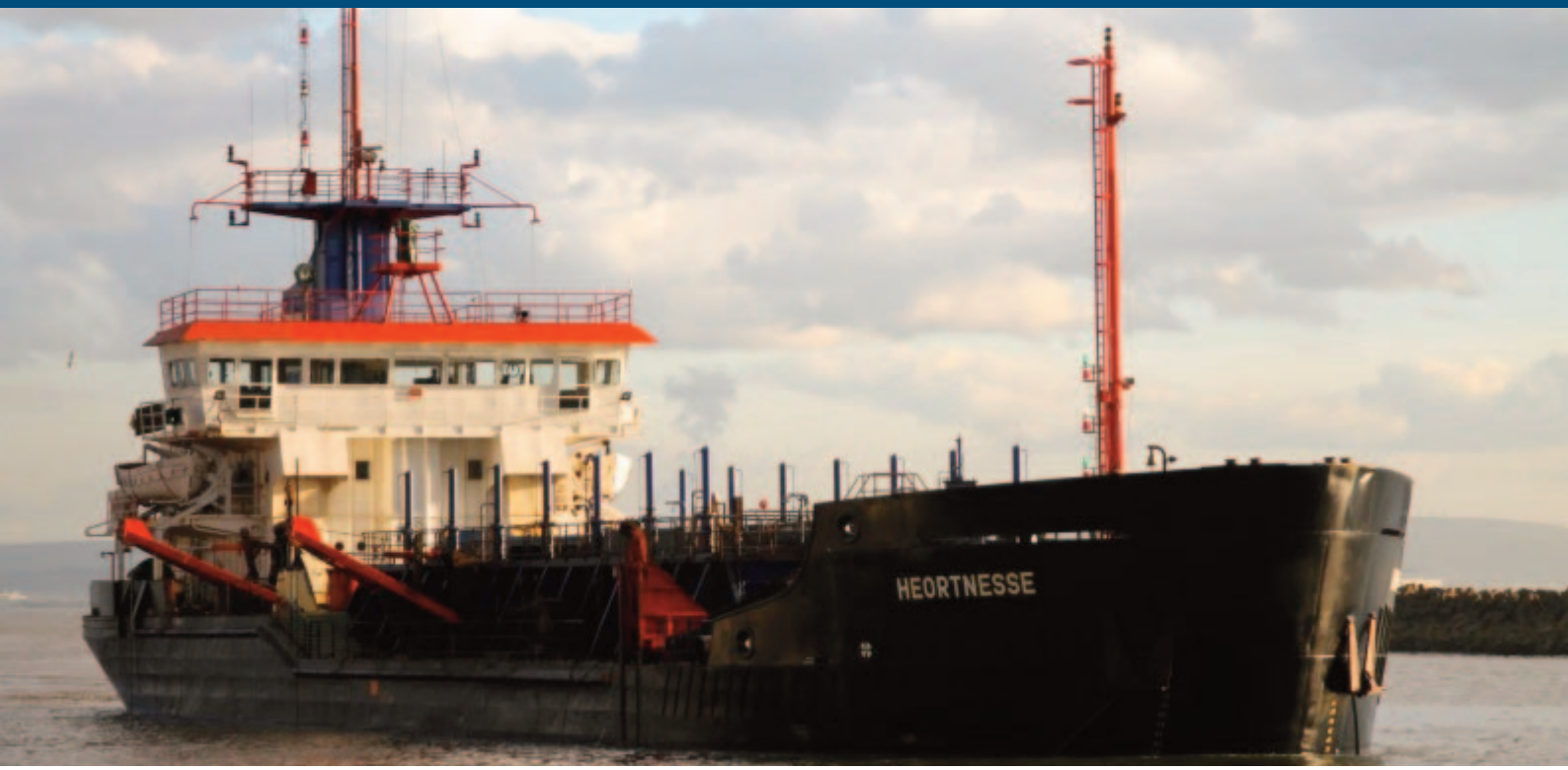
CASE STUDY

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Heortnesse Dredger Life Extension Project



Electrical Power, Propulsion, Dredging & Integrated Control, Automation & Monitoring System Upgrade.

Built in 1979 by Scheepswerf Verschure (IHC), Heortnesse is a diesel electric trailing suction hopper dredger owned and operated by PD Ports. She is responsible for maintaining critical navigation channels in the Tees Estuary and for ensuring safe navigation in and out of Teesport, one the UK's largest commercial ports.

At over 40 years old and after a long life providing critical infrastructure maintenance services, her hull and steelwork remained in very good condition and good enough for many more years of dependable service. However her equipment and systems were obsolete and no longer maintainable. Due to her overall condition, it was determined that a life extension of around 17 years was a practical and cost effective alternative to retirement and replacement, although this would involve replacing most of her essential equipment and systems.

Bidding against fierce international competition, including some of the best known names in marine power generation, propulsion and automation MJR Power & Automation was awarded the contract from A&P Group in 2019 to design and replace the vessels entire diesel electric propulsion, dredging and automation plant.

MJR Power & Automation
85-88 Willows Court, Teesside Industrial Estate, Thornaby, Stockton-on-Tees, TS17 9PP, UK
Head Office +44 (0) 1642 762 151 | Aberdeen +44 (0) 1224 507 082

www.mjrpower.com

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Engineering was carried out at MJR's Teesside facility during the last quarter of 2019 including full design approval by Lloyds Register of Shipping with system build and FAT during the first quarter of 2020.

Over a six week period in March 2020 in the midst of the COVID-19 pandemic with restricted working conditions and access, MJR safely disconnected, removed, replaced and installed the following systems:

- **Main & Auxiliary Propulsion Variable Speed Drives – 2 x 1.5MW + 1 x 500kW**
- **Dredging Pump Variable Speed Drive – 1 x 1.2MW**
- **Flushing Pump Starter - Upgrade to Soft Starting (500kW)**
- **Dredging Control System**
- **Main Hydraulic Power Unit Remote Control System**
- **Diesel Engine/Generator Control & Protection Systems**
- **Diesel Engine Instrumentation & Sensors**
- **Machinery Alarm & Monitoring System**
- **Bridge Navigation & Dredging Control Consoles**
- **Engine Control Room Consoles**
- **24 VDC Automation Battery and Power Distribution System**

At the centre of the system upgrade was the MJR MAP-OE™ Integrated Machinery Automation & Control System that was installed together with an advanced Power Management System to automate the Ship's electrical power generation and distribution system. Figure 1 below shows the replacement Bridge Navigation Console and Dredging Control Consoles together with integrated MAP-OE™ 21" Colour Touch Screen Operator Stations.



Fig. 1 Replacement Bridge & Dredging Navigation Console



Fig. 2 MAP-OE™ home screen on the Bridge Operator Station

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MJR was contracted to deliver a complete turnkey package including engineering, procurement, installation & commissioning as follows:

Basic & Detailed Hardware & Software Design of:

- Propulsion Variable Speed Drive & Remote Control System
- Dredging Variable Speed Drive & Remote Control System
- Hydraulic System
- Integrated Machinery Automation & Control System
- Power Management System
- Diesel Engine Supervision & Safety System
- Bridge, Dredging & Engine Control Room Consoles

Work on Board:

- De-commissioning and stripping out of the existing equipment and preparation for installation of the replacement system
- Cable pulling
- Installation and integration of the new equipment
- Commissioning, Harbour Trials and Sea Trials with Owner and Class.
- Handover and Training

Design Approval by Lloyds Register of Shipping Construction & FAT in MJR's Teesside Facility, inc.:

- System Construction & Assembly
- Hook Up & FAT with Client and Class
- Disassembly, packing and shipping of the system to the ship



Replacement Engine Control Console together with 2 x redundant integrated MAP-OE™ 21" Colour Touch Screen Operator Stations.

Fig. 3 Replacement Engine Control Room Console

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Main Switchboard & Power Management System Upgrade

The existing main 660V AC switchboard was controlled manually with no automatic generator synchronising, switching and load sharing and no automatic means of matching power generation capacity to load demand.

This resulted in the engineers having to continually monitor the electrical power demand of the vessel when it was dredging and continuously control the generation plant manually to match the load conditions. This required full time engineering supervision and intervention, time that could be spent carrying out routine maintenance tasks.

In order to automate this highly manual process the main switchboard was modified to add a full power management system, integrated with the MAP-OE™ IAMCS system to provide:

- **Load dependent start/stop of generators**
- **Fully automatic synchronising and load sharing of generators**
- **Automatic propulsion & dredging system load reduction for blackout prevention**
- **Automatic blackout restart**
- **Heavy consumer start interlock**
- **Sophisticated generator protection & safety**

This dramatically reduced the requirement for operational input from the Ship's engineers and provided enhanced levels of safety for the ship and its machinery.

Figure 4 below shows the completed switchboard upgrade with power management controllers installed for each generator together with replacement generator instrumentation. The power management and instrumentation upgrade for one generator is further depicted in Figure 5 overleaf.



Fig. 4 Main Switchboard with Power Management System Conversion

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Generator Control system & Instrumentation Upgrade

Together with the main switchboard upgrade, each of the three generator engines was fitted with a digital control unit for engine control and safety (see Figure 6) with all engine sensors and instrumentation replaced, including:

- Lube oil pressure transmitters & switches
- Jacket water temperature transmitters and switches
- Main bearing temperature transmitters
- Engine exhaust gas sensors

Propulsion & Dredging System Variable Speed Drive Upgrade

Due to the obsolescence of the propulsion and dredging variable speed drives all drives were replaced, including switchgear, busbars, protection, filters, chokes and their control systems. Following a detailed survey of the vessel, it was determined that the existing drive cubicles were suitable for installation of the replacement drive hardware and could be re-used rather than replaced. The new drives and auxiliary switchgear and control gear was pre-built onto drop in frames and chassis plates that enabled the full system to be hooked up and tested at MJR's facilities. This enabled an extensive FAT to be carried with the Owner and Classification Society prior to installation on the vessel. It also saved time when installing the new equipment as the pre-built chassis frames and drives could be dropped into the existing cubicles once the old equipment had been removed.

For MJR this made the installation far more complex and difficult than simply providing new drive cubicles, however it saved the owner a significant cost as replacing the cubicles would have been extremely disruptive and expensive due to the steel work, piping and electrical systems removal and reinstatements that would have been required.



Fig. 5 Generator Power Management Unit



Fig. 6 Engine Control & Protection System

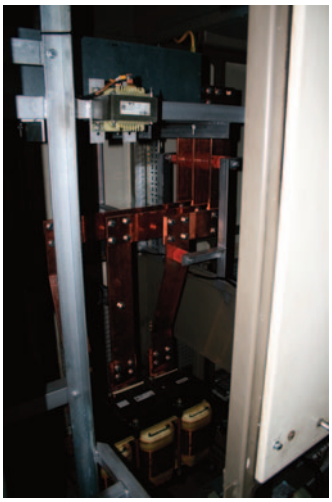




Fig. 7 Propulsion Converter Replacement

Figure 7 shows one of the replacement 1.5 MW DC propulsion converters built into the existing drive cubicle.

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MAP-OE™ Integrated Machinery Automation & Control System

At the heart of the upgrade is MJR's proprietary Marine Automation Platform, MAP-OE™ developed over a number of years and already deployed successfully on a number of retrofit marine and offshore projects.

Unlike many other similar products on the market, the system is built around commercial off the shelf marine type approved industrial control hardware along with MJR developed application software that does not tie the owner into only having one line of support. This protects the ship owner and provides a system that is more widely and openly supported.

The system provides high levels of redundancy and automation with a sophisticated and intuitive user interface enabling the Ship's crew to operate the systems with safety and convenience. Advanced diagnostics are also included to assist the crew with identification and diagnosis of machinery problems when they do arise.



Fig. 8 Home Screen



Fig. 9 Propulsion Group

The system is navigated from 'App' style home screen (touchscreen + keyboard) where the various equipment and machinery groups can be selected from icons – see Figure 8.

Selecting the PROPULSION group - Figure 9, provides the operator with a mimic screen showing the propulsion demand, power limitation and key electrical data for the propulsion motors.

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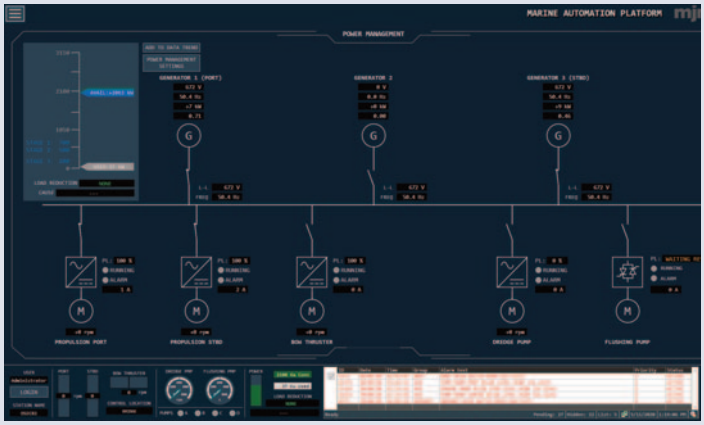


Fig. 10 Power Management Group

By selecting the POWER MANAGEMENT GROUP - Figure 10, the operator can monitor the Ship's electrical network single line diagram showing the status and electrical parameters for the main generators, propulsion and dredging pump motors and their variable speed drives. The total power available in the network can also be seen together with any power limitation applied. The electrical plant can also be controlled directly from this screen providing the operator has the necessary login authority.



Fig. 11 Engines Group

The ENGINES group - Figure 11, allows the critical temperatures and pressures of each engine to be monitored together with bar graphs for exhaust gas temperature deviations and engine/generator status indication.



Fig. 12 Dredging & HPU Group

For monitoring and control of ancillary systems, in this application the dredging system, the DREDGING & HPU group can be selected - Figure 12. This provides a dredging dashboard allowing the dredging system HPU and valves to be remotely controlled together with the main dredge pump and flushing pumps.

The animated mimic provides the operator with visual feedback of the valve positions and pipe flow with gauges for pressure and flowrate and a bar graph of dredge pump output and key electrical parameters of the pump motors.

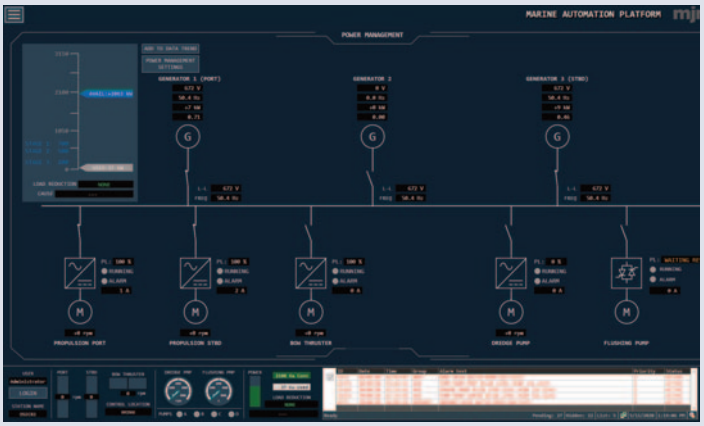


Fig. 13 Alarms Group

A dedicated ALARMS group is provided - Figure 13, that allows the operator to view the alarm summary.

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Fig. 14 Trending & Data Analytics



Fig. 15 Engineering & DIagnostics

The system is equipped with a sophisticated data historian module - Figure 14, which allows real time trending of all system parameters together with storage of all historical data to allow retrospective data analysis and reporting.

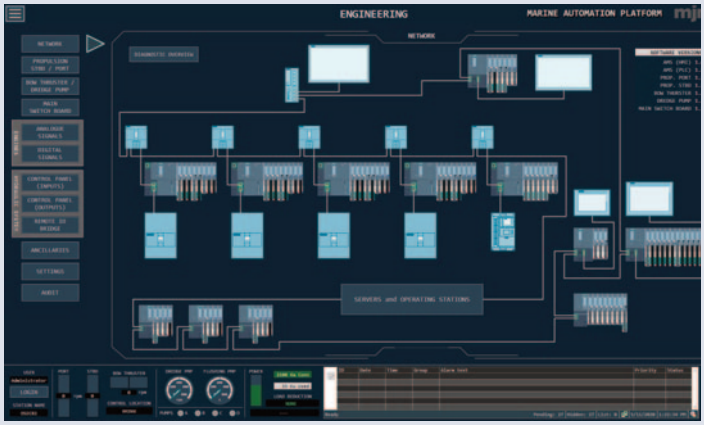


Fig. 16 Network Overview

Extensive real time network diagnostics are provided that detect any anomalies on the network and indicate these graphically on the network overview page - Figure 16, to lead the engineers intuitively to the source of any problem.

The system operates on a redundant Profinet® ring network that can be either implemented in copper or fibre.

Connectivity to third party systems and equipment

The system can interface to a wide range of third party equipment and systems for centralised monitoring and control and can support all proprietary fieldbus protocols for example:

- **Modbus**
- **Profibus**
- **MPI**
- **CAN**
- **Ethernet IP**
- **OPC UA**
- **RS323/422/485**
- **Ethernet Powerlink**

Most other protocols can also be accepted for interfacing to auxiliary systems around the vessel.

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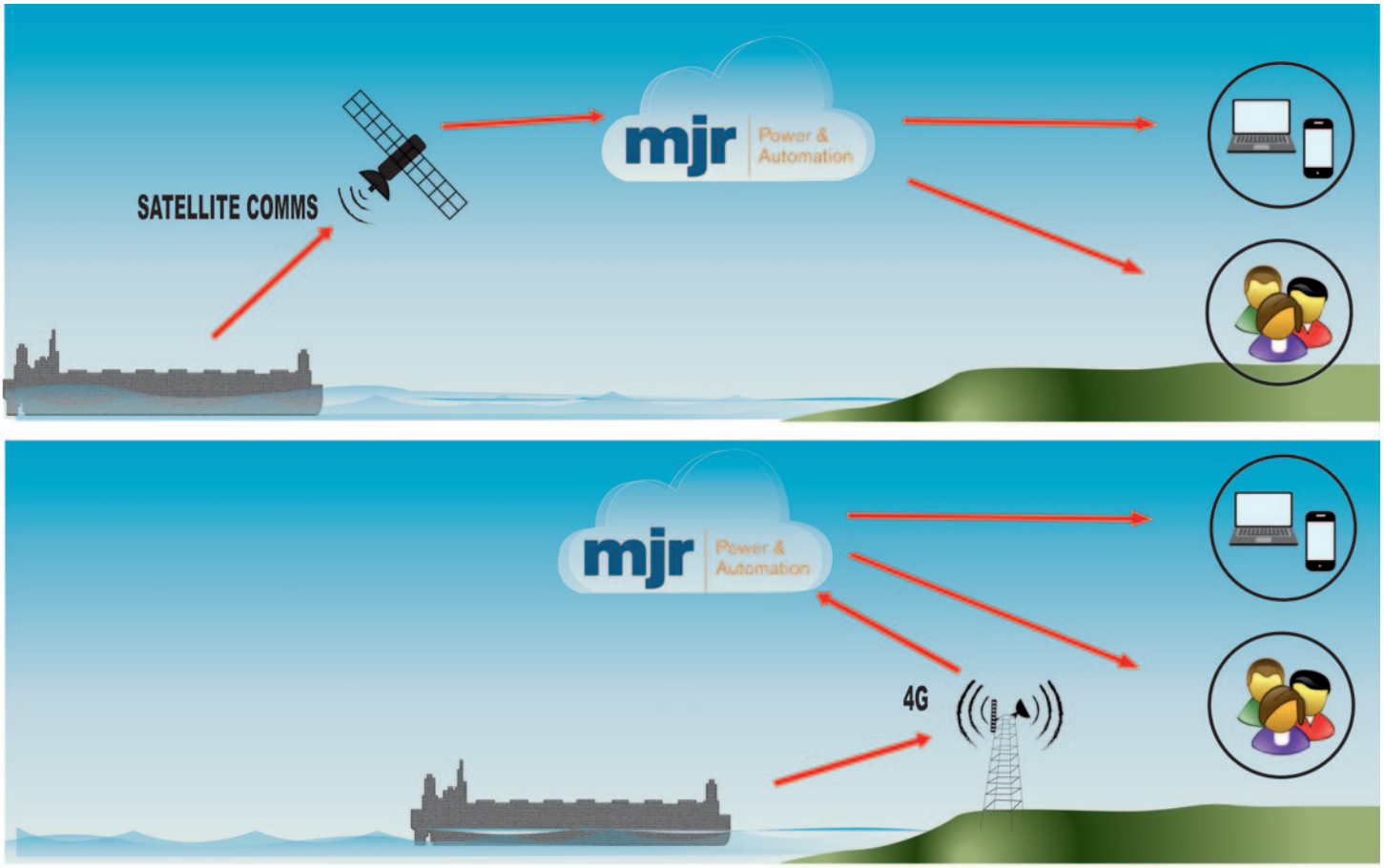
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Remote Access

The system is prepared for remote connectivity that can be provided by either a 4G router when nearshore or in port, or interfaced to the Ship's satellite broadband system if one is available. This enables remote maintenance and troubleshooting to be carried out without the expense and delay of a service engineer having to travel to the vessel.

Data can also be delivered from the Ship's system to the Ship Owner via MJR's secure cloud based data access portal and can be used for integration into planned maintenance and business management systems. If required the ship owner can also access and view the the system operator stations in real time.

The remote connection is made over a secure VPN tunnel that prevents unauthorised access.



Marine & Offshore Electrical Power and Automation Engineering

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The Heortnesse project builds from previous similar MJR Propulsion & Power System upgrades including:

- **Design & replacement of the Rotary/Static Excitation & Magnetic Amplifier system on the Ward Leonard DC Propulsion System of SV John Lethbridge with a fully electronic Field Excitation System**
- **Design & replacement of the Power Management and Generator Excitation System on the Main Propulsion Generators of the Portuguese Navy's Survey Vessel NRP Gago Coutinho**
- **Design & replacement of the Main and Auxiliary Propulsion converter and control system on SV Corystes, a UK fisheries patrol and research vessel.**



NRP Gago Coutinho



SV John Lethbridge



SV Corystes

> "Designing and retrofitting complex marine systems on this scale and with this level of complexity requires many years of experience and lessons learned. With tight timescales and no margin for error, right first time is the only option. The successful delivery of this project, despite the challenges with the COVID-19 pandemic further illustrates MJR's growing reputation as the partner of choice for demanding marine projects."
>
> **Paul Cairns, Managing Director of MJR Power & Automation.**

For further details please contact:

sales@mjrcontrols.com or call +44 (0) 1642 762 151

www.mjrpower.com